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Teacher certification and student achievement in Swedish compulsory schools

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Teacher certification and student achievement in Swedish compulsory schools*

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Abstract

This study examines how the teaching staff composition with respect to certification affects student achievement in compulsory Swedish schools. The share of non-certified teachers in compulsory schooling has increased dramatically during the last decade, starting a large debate about school quality. We apply an instrumental variable approach to estimate the causal effect of the percentage of non-certified teachers on student achievement. We find, in our preferred specification, that a one percentage point increase in the share of non-certified teachers is expected to decrease the average student's *GPA* ranking with about 0.6 units. A substantial effect if one considers the large differences in certification rate that do exist between schools and municipalities. The effect also appears to be stronger for students with highly educated parents.

Keywords: Teacher certification, teacher quality, student achievement, instrumental variable
JEL-code: I21

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1 Introduction

The debate on school and educational quality is usually centered on questions about teachers' different characteristics such as education, experience and certification. Teacher quality is considered to be one of the most important factors affecting student achievement, and is a central notion in the shaping of school and education policies. Despite the consensus that teachers are important, the opinion on what teacher quality exactly means and which teacher characteristics that are the most important is not unanimous among debaters, politicians and researchers. The existing literature does not present a consistent picture regarding these questions and the need for more evidence is large.

One frequently discussed aspect of teacher quality is certification. The definition of teacher certification usually differs between countries and sometimes also between districts within the same country. However, there still is a common feature, namely that a certification is assumed to result in better qualified teachers. Such a certification is therefore supposed to assure a lower bound on teacher quality, in that way ensuring the absence of "poor quality teachers" in schools. Two main arguments are often posed as supporting this perception. Firstly, it is argued that a formal teacher education, and therefore the teacher certification, improves an individual's teaching specific human capital. This is probably the effect people most often refers to when arguing in the favor of a teacher education or certification. Secondly, a teacher certification is often thought to be an effective screening devise to achieve higher teacher quality. Since becoming certified is costly, only people with relatively better teaching characteristics, and therefore better chances of completing the required education, choose to invest in such an education. The certification hence works as a "quality signal". In the light of these arguments students exposed to teachers without a formal certification are supposed to obtain worse results than students whose teachers are certified. However, it has also been argued that certification requirements may discourage potentially effective teachers from entering the profession, in that way actually lowering the quality of the teaching staff.[1]

There is little evidence on the effectiveness of formal certification relative non-certification, and studies examining the direct relationship between certification and student achievement are scarce. The existing literature does not

[1] See for example Angrist & Guryan (2004) and Ballou & Podgursky (1998).

present a consistent picture of the effects of certification on student achievement; the results are contradictory and quite controversial. A common problem is that many of the existing studies are built on specifications subject to biases from determinants of achievement other than certification status. At any point in time there are several factors that affect achievement and that complicate the estimation of the effect of teacher certification (and other teacher characteristics) and might therefore bias the results. Potential non-random sorting of families among schools, of students among classes and of teachers among schools are examples of factors that may lead to biased estimation results when using register data. If certified teachers search for positions at good schools/classes, good schools search for certified teachers and good students apply for good schools, direct comparisons would not identify the causal effect of teacher certification on student achievement since students in different parts of the achievement distribution are taught by teachers of different quality.

Another problem with a large part of the existing studies is that they are conducted on U.S. data where the definition of teacher certification varies largely across states.[2] In general, omitting variation in state policy that may be correlated with teacher characteristics will again result in biased estimates.

The effectiveness of teacher certification has been discussed by Goldhaber & Brewer (2000, 2001) and Darling-Hammond, Berry & Thoreson (2001), among others, and the limitations of much of the studies on teacher certification are summarized in Wayne & Youngs (2003). In a recent study Kane, Rockoff & Staiger (2006) finds that teacher certification on average has at most small impacts on student test performances. However, among teachers with the same certification status, they find large and persistent differences in teacher effectiveness. Clotfelter, Ladd & Vigdor (2006) also finds positive and significant effects of certification on student achievement.

With the present study we aim at contributing to the existing literature by analyzing how teacher quality, measured as the percentage of non-certified teachers, affects student achievement in Sweden. More specifically we study the effect of a formal teacher education, i.e., certification, on students' grade point averages. The study is motivated by the observation that the percentage of non-certified teachers in Swedish public compulsory schools increased considerably during the last decade, from 7.2 percent in 1995/96 to 17.2 per-

[2] Moreover, some states issue alternative certificates, some of them being based on different criteria from the certificates issued by traditional training institutions.

cent in 2003/04.[3] This development has been reported as alarming. Using information on teachers active in the Swedish public compulsory schools and on students completing ninth grade during the time period 1997/98 until 2003/04 we identify the causal effect of the share of non-certified teachers on student achievement by avoiding the methodological problems mentioned above. Firstly, by using Swedish data, the "state policy" bias will not constitute a problem in the present study. Certainly, in Sweden there are 290 municipalities but these do not differ in terms of teacher certification policies. Secondly, we manage to deal with selection problems and to mitigate and avoid the potential endogeneity problems[4] through; (i) controlling for school/municipality characteristics and student characteristics, (ii) adding school fixed effects to the model and (iii) employing an instrumental variable approach. Our preferred model is an instrumental variable approach that is supplemented by school fixed effects. The relevant instrument is constructed using the unemployment among certified teachers and a temporary special government grant, the Wärnersson Grant (*WG*). This grant was instituted to increase personnel density in schools and, fortunately for evaluation purposes, the grant frame was based solely on demographical aspects that could not be affected by schools or municipalities, at least not in the short run. Moreover the receivers of the grant, i.e. municipalities, were only allowed to use the additional resources for employment of school personnel. Thus, the introducetion of the *WG* meant an exogenous demand chock for teachers, certified as well as non-certified. However, the effect of the *WG* on the teaching staff composition depends on the availability of certified teachers that can be employed. It is established in Andersson & Waldenström (2007) that the *WG* is correlated with the share of non-certified teachers and also that the supply of certified teachers is restricted (lower than the demand for certified teachers) and differs between local labor markets (LLMs). It is also shown that the share of non-certified teachers increases more in LLMs characterized by low unemployment among certified teachers than in LLMs where the certified teacher unemployment is

[3] In Sweden, a certified teacher signifies a teacher who has obtained a teacher certification by attending and completing one of the teacher education programs provided by universities and university colleges. There is also the possibility to supplement a minor or major in a subject with a minimum of 1.5 years of preparation in pedagogy, didactics and teaching practice. Regardless of the choice of certification route, teachers are regarded as equally certified as long as the route has been fulfilled. A more extensive description of the Swedish teacher certification process is provided in Andersson & Waldenström (2007).

[4] A broader discussion about potential endogeneity problems is provided in section 3.

high. In the present paper we argue that the variation caused by the introduction of the *WG* in combination with the teacher unemployment is exogenously determined and does not affect student achievement. Thus the interaction term between the *WG* and the teacher unemployment constitutes a valid instrument and is used in our empirical analysis.

The results from our preferred specification show a significant positive effect of teacher certification on student achievement. We argue that this can be viewed as a lower bound of the effect of a formal teacher education or certification on student achievement. The effect also seems to be stronger for students with highly educated parents. The estimated effect is a total effect that captures both the teacher specific human capital enhancing effect and the screening effect. Analyzing for example changes in the curriculum of the teacher education would allow the identification of the teacher specific human capital enhancing effect, while a broadening of the admission to the teacher education would make it possible to identify the screening effect. This is however not the scope of this paper.

Throughout the paper we address our findings as the effect of certification on student achievement. However, it is important to be aware of the fact that the results may reflect some influence from teacher experience. Certification and experience are highly correlated and it is difficult to separate them from each other. It could therefore be hard to form policy implications regarding the effect of teacher certification on student achievement from our findings.

The research on other teacher characteristics apart from certification status, such as education and experience, is more comprehensive but still contradictory and the evidence of which teacher characteristics that matter the most is not consistent. Teacher education and experience usually account for salary differentials and are thus thought to be related to teacher productivity. By aggregating the results across studies through 1994 in the United States Hanushek (1997, 2003) shows that neither teacher education nor teacher experience has a strong systematic relation to student achievement, even though experience shows a more positive relation. The summary presented by Hanushek reports that through 1994 only 14 percent of the estimates of teacher education on student achievement were significant, five percent showing a negative relationship and nine percent showing a positive one. Among the estimates of teacher experience on student achievement 34 percent were statistically significant, 29 percent showing a positive effect and five percent a negative one. More recent studies that are not included in this summary do not

show a very different pattern of results. Krueger (1999) for example, uses an experimental approach where teachers were randomly assigned to classes and concludes that teacher education has no impact on test scores while teacher experience affects output for the youngest students but not later on. Rivkin, Hanushek & Kain (2005) reach similar conclusions and find that experience is only statistically significant in the initial years of teaching. Moreover they show that high quality teachers can compensate for initial student preparation differences related to different family backgrounds. Rockoff (2004) gets large and statistically significant estimates for the importance of teachers when he controls for fixed teacher quality. According to Rockoff's results, one standard deviation increase in the teacher fixed effect distribution results in improved student performance by 0.1 standard deviations. Moreover Rockoff shows that experience has a positive and statistically significant effect on reading test scores.[5]

The remaining of the paper is structured as follows; in section 2 we present the data, variable specifications and definitions. Also a brief description of the Wärnersson grant is included in this section. The econometrical methodology and our instrumental variable are discussed in section 3. We present the results in section 4 and conclude the paper in section 5.

2 Data and variable specifications

The study extends over the time period 1997/98–2003/04 and the population of interest is based on the Grade nine register (*Årskurs9-registret*) that covers all students who completed ninth grade of the Swedish public compulsory schooling during these years.[6] Except data from the Grade nine register, the data set is composed upon data from the Teacher register (*Lärarregistret*), the IFAU database and the HÄNDEL database. These databases have been matched together using students' and teachers' unique identifiers as well as municipality and school codes. Additional data from Statistics Sweden and the Swedish National Board for Education (*Skolverket*) is also used.

From the Grade nine register we retrieve information about students' year and month of birth, the year when they completed ninth grade, the school they attended and the municipality where the school were situated. The register also provides us with these students' grades in all subjects as well as their grade

[5] Other relevant studies are Goldhaber & Brewer (1997) and Hanushek, Rivkin & Kain (2001).
[6] Swedish compulsory schooling is nine years long.

point averages (*GPA:s*). The *GPA* is the sum of a student's 16 best grades and varies between 0 and 320. For each student cohort (each year) we percentile rank the *GPA* in order to make different measures comparable[7], which also implies that the effect estimates are normalized and can be compared to previous research. Except *GPA*:s we also use grades in core subjects (English, Swedish and Mathematics) as dependent variables. Students need to pass in all these three core subjects to be eligible to apply for high school.[8]

The Teacher register is administrated by Statistics Sweden and provides information about all teachers employed in public as well as independent schools in Sweden. From this register we extract information about teachers' certification status and obtain three different certification categories: teachers teaching within their area of certification (*certified* teachers), teachers teaching outside their area of certification (*out-of-field* teachers) and teachers without any teaching certification (*non-certified* teachers or *out-of-license* teachers). We treat the *certified* and *out-of-field* teachers as certified since both groups hold a formal teacher education.[9] Besides certification status, the Teacher register provides information about the teachers' age, gender, range of duty, type of appointment, school and municipality code, and whether they teach in a public or independent school. Beginning in the academic year of 1999/2000 the register also contains information on teacher experience which is measured as the number of active years in teaching. Further, using the Teacher register we are able to calculate the number of full time equivalent teachers at the school level[10] and by using the numbers of student in every school, which is reported in the School register (*Skolregistret*), we are able to calculate the teacher density defined as the number of full time equivalent teachers per 100 students.

Part of the data set used in this study is build upon information available in the IFAU database[11] from which we extract data on background characteristics of students and their parents such as parental education and the students' and parents' ethnical background. Students' ethnical background is indicated by a dummy variable that takes the value one if the student has immigrated to Sweden within five years before he or she completed ninth grade. We also

[7] By percentile ranking the *GPA:*s we also account for potential grade inflation.
[8] Students also take standardized tests in these subjects.
[9] The quantitative results stay unchanged if out-of-field teachers are treated as non-certified.
[10] The extent of a teacher's appointment is reported as percentage of a full time appointment.
[11] This database was created during 2000–2001 by The Institute for Labour Market Policy Evaluation (IFAU) in co-operation with Statistics Sweden. The individuals can be traced longitudinally through the educational system and on the labor market.

create a dummy variable that takes the value one if a student's both parents are born abroad. Parental education is divided into four groups; (i) a maximum of nine years of education, (ii) high school education, (iii) a maximum of two years of university education and (iv) more than two years of university education, and is observed separately for the mother and the father. In those cases where information about parental education is missing this is reported by a dummy variable.[12] The IFAU database only contains information on education up until 2003. For convenience we assume the educational level of parents whose children completed compulsory schooling in 2004 to be the same as in 2003.

The econometric framework used in this study involves an instrumental variable approach where the instrument is the interaction between the unemployment among certified teachers and the *WG*. The first part of the instrumental variable is calculated from the HÄNDEL database[13] that contains all unemployment spells registered at the Public Employment Service (PES) offices.[14] Since the HÄNDEL database also reports the type of job an unemployed individual is searching for we restrict the teacher unemployment measure to specify unemployed certified teachers who report that they are searching for a teaching job.[15] We choose to define the unemployment rate among certified teachers at the LLM level since teachers are mobile between adjacent municipalities within the LLM.[16]

Data on the second part of the instrumental variable, the governmental grant, *WG*, has been made available by the Swedish National Board for Education. The grant was instituted in the academic year 2001/02 and resources were distributed at the municipality level. The aim of the grant was to increase the personnel density in preschools, nine-year compulsory schools, special schools, after-school recreation centers and upper secondary schools in order to

[12] In our data set used for analysis 40,457 observations (around 7 percent) miss information of the father's educational level and 20,060 observations (around 3 percent) of the mother's educational level.
[13] Maintained by the National Labor Market Board (*Arbetsmarknadsstyrelsen*).
[14] Being matched to the IFAU database we can infer whether unemployed individuals are certified teachers or not. In the unemployment context, certification means that an unemployed individual holds a teaching degree.
[15] An alternative unemployment measure would be to count all unemployed certified teachers regardless the type of job they report to be searching for. However this measure is broader and probably not as exact.
[16] For a more detailed discussion of the unemployment measure used see Andersson & Waldenström (2006).

give children and youths increased possibilities of reaching their educational goals. Only municipalities could apply for and receive the *WG*, but they were allowed to freely distribute the grant among public and independent schools. In 2001/02 and 2003/04 all except two municipalities applied for and received the grant, while in 2002/03 all municipalities applied for and received it.[17]

A grant frame was calculated for each municipality yearly. This frame was based solely on the number of inhabitants between 6 and 18 years-of-age that lived in the municipality the calendar year preceding the grant year, i.e., the grant frame for 2001/02 is based on the number of children and youths aged 6 - 18 during 2000. The decision whether or not to approve new grants in subsequent years was based on the principle that the municipality had to increase the school personnel density compared to an index year. 2000/01 was the index year for 2001/02–2003/04.[18] The National Agency for Education might decide to stop further payments or reclaim already disbursed payments if a grant receiving municipality did not succeed in carrying out the measures that the grant was aimed for.

Municipalities had no knowledge about the consequences of exceeding the school budget or of having a high school personnel density during 2000/01, until after the end of the index year. The fact that the grant was aimed at reinforcement of the school personnel density was mentioned in both the government bill that introduced the *WG* and in the decree that the government issued later. However, they did not specify how this density should be measured. The "index year comparison" was described for the first time in the instructions from the National Agency for Education in 2001.[19] The municipalities and schools could hence not affect the personnel density in the index year.[20] The grant amounted to 628 SEK per student in 2001/02, 1,258 SEK per student in 2002/03 and 1,897 per student in 2003/04. An average school had 224 students in the academic year of 2003/04 so, if the grant was evenly distributed across schools, a typical school received around 400,000 SEK. The cost of employing a teacher on a full-time basis is about

[17] The two municipalities that did not receive the grant in 2001/02 were Österåker and Umeå. Nacka and Sundbyberg did not apply in 2003/04.
[18] The academic year 2000/01 was also the index year for the period 2004-07-01–2004-12-31. For the remaining of the grant years (up to and including 2006/07) the index year changed to 2003/04.
[19] Riksrevisionen, RiR 2005:9, p. 34.
[20] A more detailed description of the *WG* is given in Andersson & Waldenström (2007) or Skolverket (2005).

390,000 SEK per year so the grant was large enough to employ one new teacher in an average sized school.

Using information on all 9th grade students in compulsory schools over the time period 1997/98–2003/04 the original data set contains 729,701 individuals. However, when excluding all independent schools the data set reduces by 27,658 individuals. Independent schools are discharged since they could not apply for the *WG* and since a few of them have their own grading system. Also special schools, hospital schools and schools for refugees are excluded from the final sample. Moreover we exclude schools with extreme teacher density since these are likely to be misreported. This reduces our sample with another 118,345 individuals. The final sample contains a total of 583,679 individuals, i.e., yearly student cohorts of around 83,000 individuals.

Descriptive statistics for the variables used in our analysis are summarized in Table A1 in Appendix.

3 Model and econometric framework

A basic education production function could model student achievement, Y, as a function of school resource variables, S, municipality level variables, M, individual and family background variables, I, and a random error term, ε.

$$Y = \alpha_0 + \alpha_1 S + \alpha_2 M + \alpha_3 I + \varepsilon \quad [21] \qquad (1)$$

The S vector may for example contain school resource indices such as teacher density or class sizes at the school. Similarly the vector I may contain background characteristics such as age, gender, parental education, ethnicity, and other family related characteristics. If available, also the ability of teachers, students and school administrators should be included. A teacher's ability to convey knowledge in a pedagogical way, the student's ability to assimilate this knowledge and the administrators' ability to recruit adequate teachers and to match them to students in an effective way are important aspects when estimating the production of education. However, they are hard to measure and therefore often omitted in this type of estimations, which may lead to biased and inconsistent estimates.

[21] α_1, α_2 and α_3 are vectors of coefficients.

In our case we are specifically interested in the effect of teacher staff quality, measured as the percentage of non-certified teachers at the school, on student achievement. We therefore let y_{ijt} be student achievement[22] of individual i in school j in year t and assume that student achievement is increasing in teacher quality q_{jt} at school j in year t. There are two types of teachers; certified, C, and non-certified, NC. Let:

$$q_{jt}^{C} = \frac{\sum_{i=1}^{n_{jt}^{C}} q_{ijt}^{C}}{n_{jt}^{C}} \text{ and } q_{jt}^{NC} = \frac{\sum_{i=1}^{n_{jt}^{NC}} q_{ijt}^{NC}}{n_{jt}^{NC}}, \tag{2}$$

be the average quality among certified teachers and non-certified teachers at school j with n_{jt}^{C} certified and n_{jt}^{NC} non-certified employed teachers at year t, respectively. Furthermore let p_{jt}^{NC} be the percentage of non-certified teachers at the same school. Then the average teacher quality at school j will be given by:

$$\begin{aligned} q_{jt} &= (1 - p_{jt}^{NC}) \cdot q_{jt}^{C} + p_{jt}^{NC} \cdot q_{jt}^{NC} \\ &= q_{jt}^{NC} - p_{jt}^{NC} \cdot (q_{jt}^{C} - q_{jt}^{NC}). \end{aligned} \tag{3}$$

Under the assumption that average teacher quality among certified teachers is higher than for non-certified teachers, that is $(q^{C} - q^{NC}) > 0$, it is evident from equation (3) that teacher quality at school j is decreasing in the share of non-certified teachers at the school.

If the quality of the teacher staff affects student achievement in a negative way, then β_1 would be less than zero in the following regression:

$$y_{ijt} = \beta_0 + \beta_1 p_{jt}^{NC} + \varepsilon_{ijt} \tag{4}$$

This assumes that there is a direct effect of the percentage of non-certified teachers at the school on student achievement in ninth grade. In other words, we estimate the effect of a school's entire teaching staff on the ninth grade

[22] Measured as percentile ranked *GPA* or as the percentile ranked grades in the core subjects; English, Swedish and Mathematics.

students' achievement although not all teachers teach the students in the ninth grade. Hence, the effect does not take into consideration which classes a new teacher actually teaches. However, assuming that the average quality of the teaching staff in the ninth grade is about the same as the average quality of the entire teaching staff at the school, this will not affect our results.

A first step in our analysis would be to estimate β_1 in equation (4) by ordinary least squares (OLS). However, when using register data this method will most certainly result in biased estimates of β_1. The reason is due to different sources of endogeneity; p_{jt}^{NC} and ε_{ijt} are most likely not independent of each other.

We have three main sources of endogeneity in our model. Firstly, there may be variables correlated with the explanatory variable, in our case the percentage of non-certified teachers at a school that ought to be included in the regression but are omitted because they are unobservable or hard to measure. Secondly, there may exist non-random sorting of students and teachers into schools and of teachers over students. Parents, school administrators, teacher and politicians at different levels make non-random choices that affect the distribution of students and teachers across schools and classes. Parents attaching great importance to (high quality) education may influence the school resources by local decisions. They may locate close to and choose schools with small classes, better qualified teachers and more resources, in that case generating an upward bias in the estimated effects of school resources. Schools may use student characteristics, such as assessment to ability and achievement to place students into different programs and classes. Less advantaged students may be assigned to smaller classes and/or to certified teachers. Also teachers may sort into schools in an endogenous way. More qualified and certified teachers may choose to apply only for appointments at schools characterized by high ability students. In the presence of such non-random selections it is hard to establish the causal effect of teacher quality on student achievement and the estimates are easily contaminated by family, school and neighborhood factors. Significant positive effects of teacher characteristics on student achievement are possible to obtain although the true causal effect might be the opposite. If teachers are non-randomly assigned to classes and our specified models fail to control for ability in the class we expect the teacher certification variable to be biased downwards. Lastly, the potential endogeneity in the model may also be caused by reversed causality. It could be hard to establish weather it is the

quality of the teachers at a certain school that affects the students' results or if it is the results that affect the composition of the teaching staff.

In order to deal with the potential endogeneity we use a fixed effects estimator that includes school fixed effects. School fixed effects eliminate differences between schools that affect the certification composition and/or student achievement and that are constant over time. In other words, the fixed effects estimator make use of the variation within schools over time, in this way allowing school specific factors to be present in the model at the same time as it mitigates the endogeneity problems caused by the omission of important variables and by the non-random teacher/student/school-selection. The fixed effects model to be estimated is:

$$y_{ijt} = \beta_0 + \beta_1 p_{jt}^{C} + \gamma X_{ijt} + a_j + D_t + \varepsilon_{ijt}, \qquad (5)$$

where a_j represents the school fixed effects and D_t is a time dummy variable. The X-vector consists of time varying covariates at the LLM, municipality and school level, for example the teacher density at the school level and the overall unemployment rate at the LMM level. The vector also contains different individual student characteristics such as age, gender, immigration status and parental education.

The fixed effects approach does however *not* solve the endogeneity problem caused by reversed causality. Moreover, it provides a consistent estimate of β_1 only under the assumption of strict exogeneity, i.e., given that the idiosyncratic error is not correlated with the explanatory variables across all time periods. It may be argued that this assumption is relatively strong and that it does not necessarily have to hold. One could for example argue for the possibility that (the level of) student achievement in period *t,* and thus the idiosyncratic error in period *t*, may affect the teacher employment decision in period *t+1*. Given the assumption that the quality of a certified teacher is higher than the quality of a non-certified one, a school principal may be tempted to employ more certified teachers in *t+1* if student achievement was poor in period *t*. This would imply that student achievement in period *t* affects the share of non-certified teachers in period *t+1*. Such a behavior would result in an overestimation of the teacher certification effect on student achievement. It is nevertheless hard to prove that this type of phenomenon exists and we argue that a fixed effect approach still is relevant.

In order to deal with the reverse causality that the fixed effects model does not solve we supplement the model with an instrument variable.[23] This approach, which is less reliant on the strict exogeneity assumption, will enable us to identify the causal effect of the teaching staff certification on student achievement and provide a consistent estimator of β_1. The basic idea is to use a variable, Z, that is both relevant, i.e., correlated with the explanatory variable (in our case the percentage of non-certified teachers) and exogenous, i.e., uncorrelated with the error term. Technically this means that $\text{cov}(Z_{jt}, p_{jt}^{NC}) \neq 0$ and $\text{cov}(Z_{jt}, \varepsilon_{ijt}) = 0$. Given that there exists an instrument Z that satisfies these two conditions, the coefficient of interest, β_1, can be estimated using a two stage least square (2SLS) estimator. The system of equations to be estimated is:

$$\begin{aligned} y_{ijt} &= \beta_0 + \beta_1 \hat{p}_{jt}^{NC} + \gamma X_{ijt} + a_j + D_t + \varepsilon_{ijt} \\ p_{jt}^{NC} &= \alpha_0 + \alpha_1 Z_{jt} + \lambda X_{ijt} + \eta_{j,} \end{aligned} \tag{6}$$

where Z is the instrumental variable and η is an idiosyncratic error term.

The instrument that we use is the interaction between the *WG* and the unemployment among certified teachers, i.e., $WG_k \cdot U_l$. The two stage model can then be specified as:

$$\begin{aligned} y_{ijt} &= \beta_0 + \beta_1 \hat{p}_{jt}^{NC} + \beta_2 WG_k + \beta_3 U_l + \gamma X_{ijt} + a_j + D_t + \varepsilon_{ijt} \\ p_{jt}^{NC} &= \alpha_0 + \alpha_1 WG_k + \alpha_2 (WG_k \cdot U_l) + \alpha_3 U_l + \lambda X_{ijt} + \eta_{ijt}, \end{aligned} \tag{7}$$

where U_l is the unemployment rate among certified teachers in LLM l and WG_k is the Wärnersson grant distributed to municipal k.

The relevance of our instrument is showed in Andersson & Waldenström (2007).[24] Further, using the variation in the teacher staff composition between

[23] Since our instrument is measured at the municipality level using an IV approach without including school fixed effects would not be able to account for endogeneity within municipalities. In order for such a model to work we would have to aggregate data at the municipality level. However, such an approach would be an inferior alternative to the IV approach that includes school fixed effects.

[24] As motivated in Andersson & Waldenström (2007) the unemployment among certified teachers is a good approximation of the supply of certified teachers.

municipalities created by the *WG* together with different levels of certified teacher unemployment assure the exogeneity and thus the validity of the instrument. Our instrumental variable affects the percentage of non-certified teachers which in turns may affect student achievement, but it does not directly affect achievement. We can not find any credible reasons for why the unemployment among certified teachers should directly affect student achievement. Because of the construction of the grant we furthermore argue that the grant does not directly influence student achievement.

Assuming that certified teachers are considered to be of higher quality than non-certified teachers the exogenous teacher demand chock that the introduction of the *WG* implies should lead to an increase in the share of employed certified teachers. However, this would be possible only in the case when certified teachers are available, i.e., when the supply of such teachers is at least as large as the demand. This is however not the case in many LLM:s, but the supply of such teachers is usually restricted (see Andersson & Waldenström (2007)). The differences in the availability of certified teachers between municipalities thus determine how the *WG* affects the composition of the teaching staff. The variation between municipalities is exogenous and makes the interaction between WG_k and U_l a relevant and exogenous instrument.

The grant frame for each municipality is set independently of student achievement and only depends on the number of inhabitants in the municipality aged between 6 and 18 the year proceeding the grant year. The *WG* may in that aspect be considered as exogenous. The exogeneity of the distribution of resources within a municipality could however be open for discussion. Schools with lower results and weaker students may receive relatively more resources than schools showing better student achievement.[25] The problems that may be caused by such a resource distribution can however be mitigated by controlling for teacher density, which we also do. If the distribution of the grant, within a municipality, is based on school characteristics it will be reflected in the teacher density which is just another school resource measure (more *WG* to a school implies higher teacher density).

Under the assumption that formerly unemployed certified teachers that are employed as a result of the introduction of the *WG* are of lower quality than the already employed certified teachers, our 2SLS estimator will estimate a lower

[25] In the case of the *WG* there are however no specific requirements on which type of teachers that should be employed using the extra resources.

bound of the effect of teacher certification on student achievement. β_1 from equation (7) shows in fact the effect of certification on student achievement due to the group of teachers who are affected by our instrument, namely the new teachers that get employed because of the introduction of the *WG*.

4 Results

4.1 Teacher certification and student achievement

In this section we present the results from the estimations of the models discussed in section 3. Firstly we estimate an OLS model, secondly an OLS model with school fixed effects and lastly an IV model with school fixed effects, this last model being our preferred model. Throughout the analysis the dependent variable is the percentile ranked *GPA*. However we also report results from the estimation of our preferred model when the dependent variable is the percentile ranked grades in the core subjects (English, Swedish and Mathematics).[26]

Moreover, by dividing the sample of students into three groups according to parental education we investigate whether there are heterogeneous treatment effects of being exposed to non-certified teachers for these groups of students.

[26] All specifications have also been estimated using results on standardized tests in Mathematics, Swedish and English as the dependent variable. The results from these estimations are mostly insignificant and our instrumental variable does not seem to be relevant. This might be because of data limitations (results on standardized tests are only available for some years and for some years only for a non-representative sample of 150 schools). We therefore focus on the percentile ranked *GPA* as our dependent variable.

Table 1. The relationship between the *GPA* and teacher certification – OLS.

Dependent variable: Percentile rank of grade point average	(1) OLS	(2) OLS	(3) OLS	(4) OLS
Percent non-certified teachers (school level)	-0.118*** (0.010)	-0.106*** (0.010)	-0.013* (0.007)	-0.014* (0.008)
LLM, municipality and school level control variables	No	Yes	No	Yes
Individual level control variables	No	No	Yes	Yes
Observations	583,698	583,698	582,248	582,248
R^2	0.002	0.003	0.206	0.206

Note: Standard errors in parentheses. Standard errors are cluster corrected (cluster = school). Year dummies included. * significant at 10%; ** significant at 5%; *** significant at 1%. LLM level control variables are; overall unemployment and teacher unemployment. Municipality level control variable is the WG. School level control variables are; teacher density and number of students. Individual level control variables are; age, gender, month of birth, immigration status, parental education and parental immigration status.

Table 1 reports the results from the estimation of the OLS model when different sets of control variables are included. When controls at the individual level are not included (specification (1) and (2)) the results indicate that the percentage of non-certified teachers at the school level has a negative and statistically significant impact on student achievement. A one percentage point increase in the share of non-certified teachers is expected to decrease the average student's *GPA* ranking with 0.1 units.

When individual characteristics are added to the model (specifications (3) and (4)) the negative relation between certification status of the teaching staff and student achievement becomes much smaller and the results' statistical significance decreases to the ten percent level.

Table 2. The relationship between the *GPA* and teacher certification – OLS *with* school fixed effects.

Dependent variable: Percentile rank of grade point average	(1) FE school	(2) FE school	(3) FE school
Percent non-certified teachers (school level)	0.003 (0.008)	0.004 (0.009)	0.012 (0.008)
LLM, municipality and school level control variables	No	Yes	Yes
Individual level control variables	No	No	Yes
Observations	583,698	582,248	582,248
R^2	0.053	0.053	0.238

Note: Standard errors in parentheses. Standard errors are cluster corrected (cluster = school). * significant at 10%; ** significant at 5%; *** significant at 1%. LLM level control variables are; overall unemployment and teacher unemployment. Municipality level control variable is the WG. School level control variables are; teacher density and number of students. Individual level control variables are; age, gender, month of birth, immigration status, parental education and parental immigration status.

Because the OLS estimates most certainly are biased and inconsistent (as discussed in section 3) we include school fixed effect in order to mitigate the potential endogeneity in the model. These results are reported in Table 2. As shown, no significant effects of teacher certification on student achievement can be found. The estimated effects are very small and far from statistically significant.

Because the school fixed effects model is not able to handle all kinds of endogeneity that may be present we supplement the model with an instrumental variable, namely the interaction between the *WG* and the certified teacher unemployment, and we estimate the model using a 2SLS estimator. The results from this model are presented in Table 3.

Table 3. The relationship between the *GPA* and teacher certification – 2SLS *with* school fixed effects.

Dependent variable: Percentile rank of grade point average	(1) IV FE school	(2) IV FE school	(3) IV FE school
Percent non-certified teachers (school level)	-0.357* (0.184)	-0.465* (0.251)	-0.556** (0.273)
LLM, municipality and school level control variables	No	Yes	Yes
Individual level control variables	No	No	Yes
Observations	583,695	583,695	582,245
R^2	0.005	0.008	0.185

Note: Standard errors in parentheses. Standard errors are cluster corrected (cluster = school). Year dummies included. * significant at 10%; ** significant at 5%; *** significant at 1%. LLM level control variables are; overall unemployment and teacher unemployment. Municipality level control variable is the WG. School level control variables are; teacher density and number of students. Individual level control variables are; age, gender, month of birth, immigration status, parental education and parental immigration status.

From Table 3 we conclude that the certification status of teachers appears to matter when trying to explain student achievement measured by percentile ranked *GPA*.[27]

The results from the first specification, that does *not* include individual, school, municipality or LLM control variables, shows that a one percentage point increase in the share of non-certified teachers is expected to decrease the average student's *GPA* ranking with almost 0.4 percentile units. The estimate is statistically significant at the 10 percent level. In the second specification (2), where control variables at the school, municipality and LLM level are included, the estimated effect is larger and a one percentage point increase in non-certified teachers is expected to decrease the average student's *GPA* ranking with about 0.5 percentile units. In the last specification (3) we also include individual specific characteristics in the model. In this specification a one percentage point increase in the share of non-certified teachers is expected to decrease the average student's *GPA* ranking with about 0.5 percentile units and is statistically significant at the five percent level. We can conclude that the estimated effect is relatively stable between the different specifications.

[27] The complete parameter estimates from Table 3 are reported in Table A2 in the Appendix. The complete first stage regression estimates and the F-statistica are reported in Appendix, Table A3.

However the results reported in Table 3 may be overestimated if non-certified teachers systematically award lower grades than certified teachers, given the same student performance. Therefore, we use percentile ranked grades in the three core subjects as alternative dependent variables. Since students take standardized tests in these subjects we expect the grading procedure to be easier and more accurately assessed in these subjects. We use both a grade point average of all three core subjects (English, Swedish and Mathematics) and grades in these single subjects as the dependent variable. When studying results in only a few or single subjects the variation in the data is likely to be less, which makes it harder to get precise point estimates. The results from these regressions are similar to the results presented in Table 3.[28] The point estimates are statistically significant on around the ten percent level in all but one specification and the magnitude of the estimated effect is about the same as in Table 3. A one percentage point increase in the share of non-certified teachers is expected to impair student achievement in core subjects with between 0.3 and 0.4 percentile units. We therefore conclude that differences in grading practises between certified and non-certified teachers is not likely to constitute a major problem in our study.

The evidence provided so far indicates that students exposed to non-certified teachers perform worse than their fellows being taught by certified teachers. The importance of this result could however be hard to grasp without further discussion. For that purpose let us analyse what our estimated result means for the achievement of an average student in a municipality situated at the 95th percentile of the distribution of the share of non-certified teachers (called "the teacher certification distribution" in the remaining of the paper) compared to a student in a municipality situated at the 5th percentile of the teacher certification distribution. In the academic year 2003/04 a municipality with a position at the 95th percentile of the teacher certification distribution had around 28 percent non-certified teachers while a municipality at the 5th percentile had less than 8 percent non-certified teachers, a difference in the share of non-certified teachers of around 20 percentage points.[29] The point estimate from column (3) in Table 3, (-0.56) signify in this context that a student attending a school with a share of non-certified teachers corresponding to the 95th percentile in the teacher certification distribution receive a position in the *GPA* ranking that is 11.2 (0.56 · 20) percentile units lower than a student

[28] These results are reported in Table A4 in Appendix.
[29] See Andersson & Waldenström (2007).

who attends a school at the 5th percentile, all else kept constant. To further understand this result we can compare it with the differences in student achievement between boys and girls. It is a well known fact that girls outperform boys when it comes to student achievement. In our estimations (see Appendix, Table A2) we find that girls are expected to achieve a position in the *GPA* distribution that is 11 percentile units better than for boys, ceteris paribus. A rather large difference, but attending a school at the lower end of the teacher certification distribution instead of a school at the top of the distribution can counterbalance this effect.

Another interpretation of our results that is plausible is in relation to immigration status. Students that have immigrated to Sweden within five years before completing compulsory schooling is expected to have a position in the *GPA* distribution that is around 3 percentile units worse than other students. The difference in student achievement of attending a school at the 95th percentile of the teacher certification distribution, instead of a school at the 5th percentile in the distribution is almost four times as large as the difference between newly immigrated students and students that have lived in Sweden for a longer time.[30]

The results indicate that the percentage of non-certified teacher has a rather large effect on student achievement. These findings provide thus some support for the hypothesis that teacher certification matter for student achievement. However, the presented results may also reflect some influence from teacher experience since certification and experience are highly correlated and hard to separate from each other.[31] Certified teachers have usually much more experience than their non-certified counterparts; teachers that have invested in a certification usually stay longer within the profession than teachers that have not invested in a teacher education.[32] Therefore, and also because we can not separate the screening effect from the effect on human capital of the teacher education it is hard to draw policy conclusions from our findings. However, it could be questionable whether the large differences in the percentage of (non-) certified teachers between different schools and municipalities are defensible

[30] See Appendix, Table A2.
[31] Teacher experience is unfortunately only available from the academic year 1999/2000 and onwards.
[32] According to our data, the mean number of years of experience among certified teacher was in 2004 about 17.7 years while the corresponding number for non-certified teachers was only 4.3 years.

from a fairness point of view.[33] As discussed above, differences in student achievement related to, e.g., gender differences or immigration status can be counterbalanced by attending schools with a low share of non-certified teachers.

4.2 Heterogeneous effects

The results presented in the previous section indicate that having higher percentage non-certified teachers at a school harm student achievement. To further investigate whether students with different backgrounds are affected differently by being taught by non-certified teachers we divide the sample according to parental education. This division can be seen as an approximation for students' socio-economic status. The sample is divided into three groups; (i) students whose parents have at most have 9 years of education, (ii) students with parents where at least one parent have a high school education and finally (iii) students with parents where at least one of the parents have a university education. We apply this division on our preferred 2SLS model with school fixed effects and include municipality, school and individual level controls. The results are reported in Table 4.

[33] Especially since the Swedish school system has a goal of equal opportunities for students despite, for example, their geographical residence.

Table 4. The effect of teacher certification by family background – 2SLS *with* school fixed effects.

Dependent variable: Percentile ranked grade point average	(1) IV FE - Low educated parents	(2) IV FE - Medium educated parents	(3) IV FE - Highly educated parents
Percent non-certified teachers (school level)	-0.696	-0.343	-0.720**
	(0.483)	(0.288)	(0.363)
LLM, municipality and school level control variables	Yes	Yes	Yes
Individual level control variables	Yes	Yes	Yes
Observations	55,299	280,544	246,366
R^2	0.032	0.065	0.051

Note: Standard errors in parentheses. Standard errors are cluster corrected (cluster = school). Year dummies are included. * significant at 10%; ** significant at 5%; *** significant at 1%. LLM level control variables are; overall unemployment and teacher unemployment. Municipality level control variable is the WG. School level control variables are; teacher density and number of students. Individual level control variables are; age, gender, month of birth, immigration status, parental education and parental immigration status.

As Table 4 shows there are no statistically significant effects for the first two groups while the effect for the last group is statistically significant at the five percent level. It can thus be concluded that the only students that seems to be affected by a high percentage of non-certified teachers are students to highly educated parents. A student with highly educated parents is expected to fall with about 0.7 units in the percentile ranked *GPA* distribution when the share of certified teacher is increased with one percentage point.

This result can at first sight appear a little surprising, but could maybe be explained by the fact that although non-certified teachers may be equally good as certified teachers at giving students basic knowledge, they are not as good when it comes to preparing the top students. High achieving students are likely to be more common among those with advantageous socio-economic background, i.e., with highly educated parents.

To summarize, our findings indicate that the share of non-certified teachers in public compulsory schools do have a negative impact on student achievement. The effect is quite large and attending a school with very few non-certified teachers compared to one with a lot of certified teachers can for example counterbalance differences in performance between boys and girls.

We also find that students with highly educated parents are affected the most from being exposed to non-certified teachers.

5 Conclusions

Teacher certification have for a long time been a much debated subject. In Sweden the share of non-certified teachers has increased rapidly during the last decade and proposals to prohibit non-certified teachers on indefinite contracts have been suggested. Although teacher certification is seen as an important aspect of teacher quality, there is little evidence that it is systematically related to student achievement.

This paper provides some evidence that certified teachers are important for student achievement in Swedish compulsory schools. We estimate the effect of the percentage of non-certified teachers at a school on student achievement. In our preferred model specification we apply an instrumental variable approach with school fixed effects. We find that the average student's position in the *GPA* ranking is expected to decrease with 0.56 percentile units if the share of non-certified teachers is increased with one percentage point. That this is a relatively large effect is evident when it is related to differences in student achievement between girls and boys and also between immigrant and non-immigrant students. Attending a school with a low share of non-certified teachers can counterbalance gender differences in student achievement and also the achievement disadvantage that immigrant students may have.

When our sample is divided according to parental education we find that students with highly educated parents are the ones for which non-certified teachers are most detrimental. A one percentage point increase in the share of non-certified teachers is, ceteris paribus, expected to decrease a student with high educated parents' position in the *GPA* ranking with 0.72 units. These effects are statistically significant at the five percent level.

Our findings indicate that the teaching staff composition with respect to certification matter for the students' results. In other words we find evidence for the hypothesis that a formal teacher education, and thus teacher certification, plays a role for student achievement. However, it is important to remember that our results also may reflect the influence that teacher experience may have on achievement. Because we can not separate these effects from each other and also since we can not separate the teaching education's screening

effect from its effect on human capital makes it harder to draw policy conclusions.

These results can thus not give a definitively answer to the much debated policy relevant question of whether imposing tighter standards for employment of non-certified teachers, and even the prohibition of employing such teachers on indefinite contracts, leads to better student achievement.[34] It is possible that such measures can improve teacher quality, but it is important to keep in mind that a prohibition of employing non-certified teachers may also restrict the supply of qualified individuals. Moreover, when analyzing the power and credibility of the certification as a teacher quality measure it is important to also include aspects like the quality of the teacher education candidates, as well as the quality of the teacher education per se. Wedman, Wahlgren & Franke-Wikberg (2006) concludes in a report for the Swedish National Agency for Higher Education (*Högskoleverket*) that the Swedish teacher education is not up to the mark; students attending the education are graded higher than they should and 25 percent of the students passing the exams and receiving a certification do not have the necessary knowledge and should not have received a teacher certification.

Our results do however give rise to questions from a fairness point of view. The large differences in teacher certification between municipalities and schools are not defensible in the light of the "equal opportunities"-goal for students regardless their gender, ethnicity and family background. According to this goal student achievement should not depend on which school a student is attending or which municipality he/she resides in, but rather on his/her ability and effort. Considering our result this goal does not seem to be fulfilled.

[34] Such a proposal has been put forward by the Swedish Minister for Schools and Adult Education, Jan Björklund. More information about this can be found on http://www.sr.se/cgi-bin/ekot/artikel.asp?Artikel=1039276 and http://www.regeringen.se/sb/d/7596/a/72405.

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Appendix

Table A1. Descriptive statistics for the complete sample

Variable	Observations	Mean	Std. Dev.
Percent non-certified teachers (school level)	582,248	18.17	10.64
Wärnersson grant (municipality level), Thousands of SEK/student	582,248	0.55	0.70
Percent overall unemployment, (local labor market)	582,248	4.60	1.14
Percent unemployment certified, those searching for teacher jobs, (local labor market)	582,248	2.48	1.10
Teachers/100 students (school level)	582,248	8.11	1.16
Rank of grade point average	582,248	50.06	28.83
Grade point average	582,248	202.42	62.72
Number of students	582,248	468.08	165.45
Girl	582,248	0.49	0.50
Mother: high school education	582,248	0.49	0.50
Mother: university education shorter than 2 years	582,248	0.03	0.17
Mother: at least 2 years of university education	582,248	0.29	0.45
Mother: information about education is missing	582,248	0.03	0.18
Father: high school education	582,248	0.45	0.50
Father: university education shorter than 2 years	582,248	0.06	0.24
Father: at least 2 years of university education	582,248	0.20	0.40
Father: information about education is missing	582,248	0.07	0.25
Student immigrated within five years before completing ninth grade	582,248	0.02	0.12
Both parents born abroad	582,248	0.12	0.32
Month of birth	582,248	6.26	3.37

Table A2. Complete parameter estimates from Table 3.

Dependent variable: Percentile ranked grade point average	(1) IV FE	(2) IV FE	(3) IV FE
Percent non-certified teachers, (school level)	-0.357* (0.184)	-0.465* (0.251)	-0.556** (0.273)
Wärnersson grant (municipality level), Thousands of SEK/student	-0.261 (0.713)	-0.098 (0.783)	-0.216 (0.814)
Percent unemployment certified teachers, those searching for teacher jobs, (local labor market)	-0.434*** (0.167)	-0.490** (0.200)	-0.522** (0.214)
Percent overall unemployment, (local labor market)		0.209 (0.160)	0.302* (0.171)
Ln(number of students)		2.983* (1.813)	3.211* (1.934)
Ln(teachers/100 students)		4.017 (2.832)	5.433* (3.079)
Mother: information about education is missing			2.259*** (0.413)
Mother: high school education			7.221*** (0.118)
Mother: university education shorter than 2 years			15.077*** (0.235)
Mother: at least 2 years of university education			19.043*** (0.149)
Father: information about education is missing			0.531*** (0.203)
Father: high school education			4.525*** (0.107)
Father: university education shorter than 2 years			13.404*** (0.181)
Father: at least 2 years of university education			15.825*** (0.140)
Both parents born abroad			-0.728*** (0.221)
Student immigrated within five years before completing ninth grade			-2.938*** (0.527)
Girl			11.290*** (0.108)
Month of birth			-0.427*** (0.011)
Age			-11.653*** (0.183)

Dependent variable: Percentile ranked grade point average	(1) IV FE	(2) IV FE	(3) IV FE
Year 1998	-4.797** (2.244)	-5.807** (2.859)	-6.302** (3.078)
Year 1999	-3.573** (1.694)	-3.712** (1.878)	-3.618* (1.986)
Year 2000	-3.114** (1.511)	-3.071* (1.632)	-3.525** (1.710)
Year 2001	-2.059 (1.258)	-1.585 (1.332)	-1.752 (1.370)
Year 2002	-0.920 (0.849)	-0.311 (0.997)	-0.335 (1.036)
Year 2003	-0.497 (0.462)	0.060 (0.641)	0.041 (0.681)
Observations	583,679	583,679	582,245
R^2	0.005	0.008	0.185

Table A3. First stage regression results from Table 3.

	(1)	(2)	(3)
Wärnersson grant (municipality level), Thousands of SEK/student	2.864**	2.643**	2.646**
	(1.153)	(1.160)	(1.161)
Percent unemployment certified teachers, those searching for teacher jobs, (LLM)	-0.203	-0.249	-0.248
	(0.214)	(0.220)	(0.220)
Wärnersson grant (municipality level) · Unemployment certified teachers (LLM)	-0.452***	-0.367***	-0.368***
	(0.129)	(0.131)	(0.131)
Percent overall unemployment, (LLM)		0.263	0.263
		(0.204)	(0.204)
Ln(number of students)		5.296***	5.308***
		(1.625)	(1.626)
Ln(teachers/100 students)		10.188***	10.193***
		(1.639)	(1.632)
Mother: information about education is missing			0.141**
			(0.057)
Mother: high school education			0.034
			(0.021)
Mother: university education shorter than 2 years			0.047
			(0.043)
Mother: at least 2 years of university education			-0.011
			(0.023)
Father: information about education is missing			0.016
			(0.035)
Father: high school education			-0.014
			(0.018)
Father: university education shorter than 2 years			-0.004
			(0.029)
Father: at least 2 years of university education			-0.014
			(0.023)
Both parents born abroad			0.048
			(0.032)

	(1)	(2)	(3)
Student immigrated within five years before completing ninth grade			-0.074 (0.072)
Girl			0.028* (0.014)
Month of birth			0.004* (0.002)
Age			0.049 (0.036)
R^2	0.40	0.42	0.42
F-value	12.33	7.80	7.85
Prob > F	0.000	0.005	0.005

Table A4. Student achievement in core subjects – 2SLS *with* school fixed effects.

Dependent variable: Percentile ranked grades in core subjects	(1) All three core subjects	(2) English	(3) Swedish	(4) Mathematics
Percent non-certified teachers (school level)	-0.413* (0.237)	-0.394* (0.221)	-0.399* (0.237)	-0.346 (0.242)
LLM, municipality and school level control variables	Yes	Yes	Yes	Yes
Individual level control variables	Yes	Yes	Yes	Yes
Observations	557,416	576,521	557,676	576,521
R^2	0.17	0.12	0.19	0.11

Note: Standard errors in parentheses. Standard errors are cluster corrected (cluster = school). Year dummies included. * significant at 10%; ** significant at 5%; *** significant at 1%. LLM level control variables are; overall unemployment and teacher unemployment. Municipality level control variable is the WG. School level control variables are; teacher density and number of students. Individual level control variables are; age, gender, month of birth, immigration status, parental education and parental immigration status.

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